MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

EPM2036 – CONTROL THEORY

(TE / RE / BE)

24 OCTOBER 2017
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions only.
2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given .
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Reduce the block diagram in **Figure Q1.1** to a single block using block diagram reduction. [16 marks]

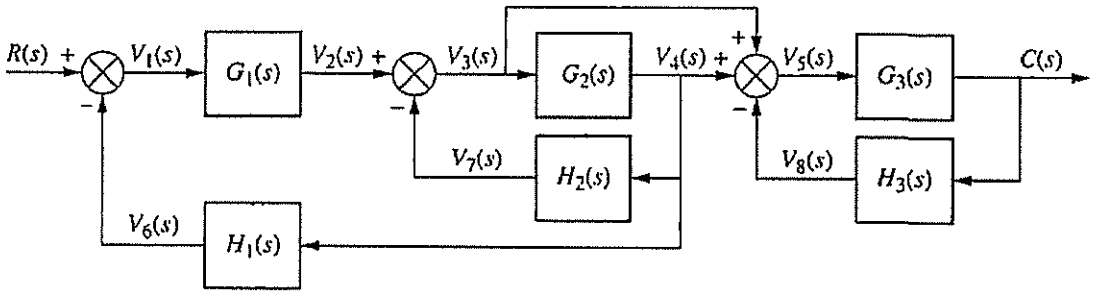

Figure Q1.1

(b) Write the mesh equations of the network shown in **Figure Q1.2**. [9 marks]

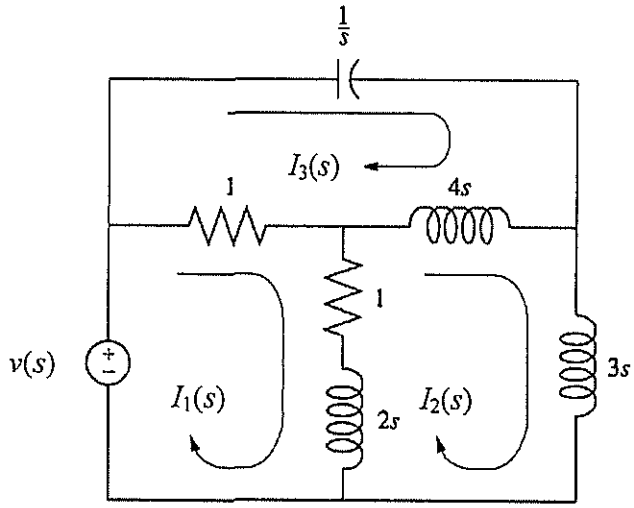

Figure Q1.2

Continued...

Question 2

(a) Determine the stability of the closed loop transfer function shown below using the Routh Hurwitz criterion approach. [12 marks]

$$T(s) = \frac{10}{s^5 + 7s^4 + 6s^3 + 42s^2 + 8s + 56}$$

(b) Consider the non-unity feedback control system in **Figure Q2.2**.

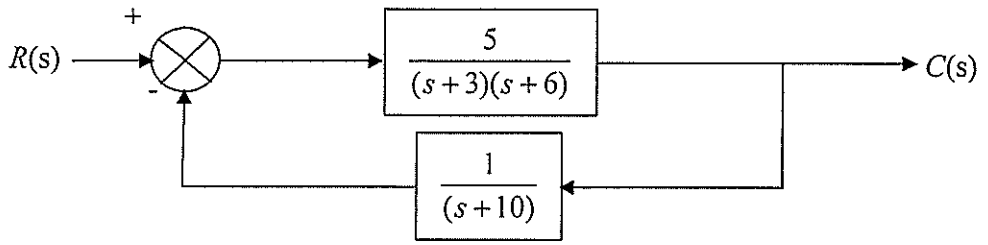

Figure Q2.2

Determine the system type and the steady-state error (e_{ss}) for the corresponding unit step input function. [13 marks]

Continued...

Question 3

a) For each of the root locus shown in **Figure Q3.1**, indicate whether the sketch can be a root locus. If the sketch cannot be a root locus, explain the reason(s) why. [8 marks]

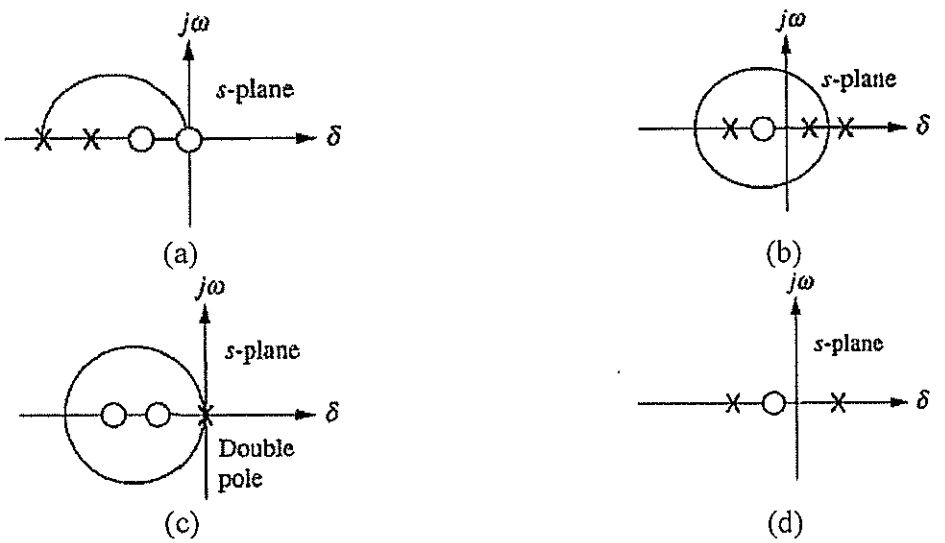

Figure Q3.1

b) Consider a unity feedback system given in **Figure Q3.2**.

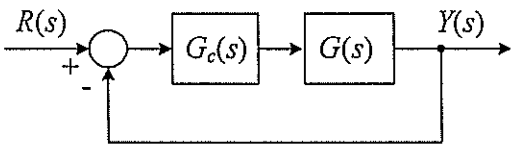

Figure Q3.2

The plant transfer function is given by $G(s) = \dfrac{1}{s(s+1)(s+2)}$ and $G_c(s)$ is the transfer function of a controller. Suppose that $G_c(s) = K$ is a Proportional controller with a constant gain $K > 0$. Sketch the trajectories of the closed-loop roots using the root locus method as K is varied from zero to infinity. In the root locus plot and supported with proper mathematical calculation, indicate clearly the following:

- starting and ending points of all branches, [2 marks]
- root loci on the real axis, [1 mark]
- angles and centroids of asymptotes, [4 marks]
- breakaway/break-in points. [5 marks]

Finally, sketch the overall root locus. [5 marks]

Continued...

Question 4

(a) Describe the Nyquist stability criterion for a closed-loop system. [3 marks]

(b) Given the following forward path transfer function of a negative unity feedback system,

$$G(s) = \frac{K}{s(s+4)(s+9)}.$$

Based on the Nyquist stability criterion, determine the stability range of K for the closed-loop system. [11 marks]

(c) A control system with Proportional-Derivative (PD) controller is shown in **Figure Q4.1**. Design the PD Controller by finding the values of K_P and K_D so that the ramp error constant K_V is 1000 and the damping ratio is 0.5. [11 marks]

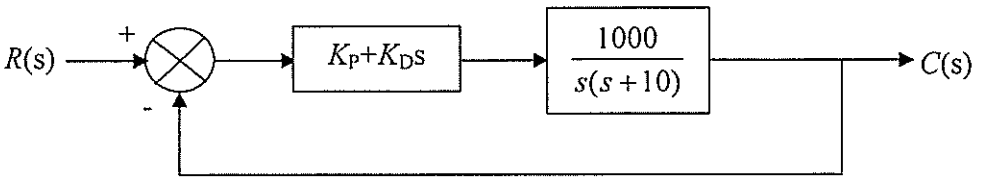

Figure Q4.1

Continued...

Appendix

$f(t)$	$F(s)$
Unit impulse $\delta(t)$	1
Unit step $u_s(t)$	$\frac{1}{s}$
t	$\frac{1}{s^2}$
$\frac{t^{n-1}}{(n-1)!} \quad (n = 1, 2, 3, \ldots)$	$\frac{1}{s^n}$
$t^n \ (n = 1, 2, 3, \ldots)$	$\frac{n!}{s^{n+1}}$
e^{-at}	$\frac{1}{s+a}$
te^{-at}	$\frac{1}{(s+a)^2}$
$\frac{t^{n-1}}{(n-1)!}e^{-at} \quad (n = 1, 2, 3, \ldots)$	$\frac{1}{(s+a)^n}$
$t^n e^{-at} \ (n = 1, 2, 3, \ldots)$	$\frac{n!}{(s+a)^{n+1}}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$\sinh \omega t$	$\frac{\omega}{s^2-\omega^2}$
$\cosh \omega t$	$\frac{s}{s^2-\omega^2}$
$\frac{1}{a}(1-e^{-at})$	$\frac{1}{s(s+a)}$
$\frac{1}{b-a}(e^{-at}-e^{-bt})$	$\frac{1}{(s+a)(s+b)}$
$\frac{1}{b-a}(be^{-bt}-ae^{-at})$	$\frac{s}{(s+a)(s+b)}$
$\frac{1}{ab}\left[1+\frac{1}{a-b}(be^{-at}-ae^{-bt})\right]$	$\frac{1}{s(s+a)(s+b)}$
$\frac{1}{a^2}(1-e^{-at}-ate^{-at})$	$\frac{1}{s(s+a)^2}$

End of Paper